

Reconstruction of large defects in vertebral osteomyelitis with expandable titanium cages

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Abstract The purpose of this study was to investigate the outcome of expandable titanium cage implantation in large defects caused by acute vertebral osteomyelitis. Twenty-five patients with acute single or multilevel spondylodiscitis were treated after radical débridement and posterior instrumentation with an anterior expandable titanium cage and bone grafting. Clinical, laboratory and radiological follow-up continued for 36 months. Within the postoperative course there was no recurrence of spinal infection. The final radiological examination showed successful fusion in all cases without implant loosening or failure. At the final follow-up after 36 months the Oswestry Disability Index was 23 ± 14 and the pain visual analogue scale 2.1 ± 1.7 . This study reveals healing and improved function after expandable titanium cage implantation in all patients. Prerequisites for optimal healing include radical débridement, provision of stability for weight-bearing, adequate bone grafting and correction of deformity using rigid implants.

Résumé Le but de cette étude est d'analyser le devenir des cages titane expansibles implantées dans le cas de

perte de substances osseuses aiguës vertébrales après ostéomyélite. Matériel et méthode: 25 patients présentant une spondylodiscite à un ou plusieurs niveaux ont été traités. Après mise à plat, instrumentation postérieure, mise en place d'une cage antérieure expansible et greffe, les patients ont été suivis pendant 36 mois sur le plan clinique, biologique et radiologique. Résultats: il n'y a pas eu de récurrence de l'infection. Le résultat radiologique a montré une bonne fusion dans tous les cas sans descellement ou échec de l'implant. Au suivi final de 36 mois, l'index d'Oswestry est de 23 ± 14 et l'échelle douloureuse visuelle analogique est de 2.1 ± 1.7 . En conclusion, cette étude permet de montrer que ces cages autorisent une cicatrisation et une amélioration de la fonction chez ces patients. Néanmoins, il est nécessaire pour obtenir ce résultat de réaliser une mise à plat, d'adapter la remise en charge, de faire une greffe également adaptée et de corriger les déformations par une instrumentation rigide.

Introduction

Large bony defects after osteomyelitis remain a major challenge in reconstructive surgery. A special entity in this regard are vertebral defects after spinal infection. High vascularity from overlying muscle and rich cancellous bone provides an optimal basis for healing of vertebral infections after surgical débridement, but complications due to access, defect size, impairment of neurological structures and spinal deformity are well known to spinal surgeons [7, 15, 20].

Depending on the size of defects, tricortical bone grafts, vascular fibula grafts and titanium cages filled with autologous cancellous bone have been used to reconstruct osteomyelitic defects of the spine [11, 13]. From earlier studies we know that the larger the bony defect is, the

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longer the time to healing will take [23]. Prerequisites for optimal healing include radical débridement, provision of stability for weight-bearing, adequate bone grafting and correction of deformity [17]. Consideration of the anterior weight-bearing and the posterior tension band are mandatory for optimal reconstruction of the spinal profile. Therefore sometimes posterior-anterior-posterior interventions may be required [19]. For more than five years newly developed implants have been available allowing anterior in situ distraction to act against the anterior compressive forces in a posterior-anterior intervention: expandable titanium cages.

To investigate whether expandable titanium cages allow an adequate reconstruction of major spondylitic defects, we followed up these patients prospectively for three years.

Materials and methods

This study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Written informed consent was obtained from all study participants. During a period of two years (2003–2004) 25 patients (16 women and nine men; age: 68 ± 11 years) with acute single or multilevel spondylodiscitis (24 lumbar, 19 thoracic and no cervical) were investigated prospectively in two spinal surgery centres. In 48% of the patients an infectious focus could be determined (five patients had an acute urinary tract infection, three had pneumonia, two had chronic erysipelas and two had a periungual toe infection). In the investigated group 57% of the patients had cardiovascular disease, 21% insulin-dependent diabetes mellitus and 13% terminal renal failure. In three of the cases the spondylodiscitis was postprocedural. Ten patients presented initially with epidural abscesses, five of whom had a spinal stenosis of $52 \pm 17\%$ of the spinal canal diameter. Neurological deterioration with sensorimotor deficits was present in seven cases.

Nine patients received antibiotic and orthopaedic treatment prior to surgery, but were operated on because of either neurological impairment or septic exacerbation. Surgical management consisted of a simultaneous combined posterior-anterior procedure ($n=20$) or a posterior-anterior-posterior staged intervention ($n=4$). In one case a single anterior procedure was performed. For posterior stabilisation a titanium polyaxial screw-rod system was used (Moss Miami, Moss Max or Expedium, all DePuy Spine, Leeds, UK). During the anterior procedure, which was performed using a conventional open approach, all patients received an expandable titanium cage (X-Tenz, DePuy Spine, Leeds, UK) with cancellous bone from the iliac crest blended with gentamicin sponges (Sulmycin, Essex Pharma, London, UK) following radical débridement and decompression. In

the case of single-level spondylodiscitis the defect size led to the choice of the expandable anterior device.

Postoperatively the patients received antibiotic treatment for 12 weeks according to the resistance spectrum. If no pathogen was found, broad-spectrum antibiotic treatment was initiated for 12 weeks. No bracing was necessary due to the high primary stability of the construct. Follow-up dates were six weeks, 12 weeks, six months, one year and three years postoperatively. At each follow-up lateral and anteroposterior (AP) X-rays were performed. Furthermore white blood cell (WBC) count and C-reactive protein (CRP) concentration were determined with standard laboratory protocols. Pain visual analogue scale (VAS) and Oswestry Disability Index (ODI) were also investigated after one and three years.

Statistical testing was performed with Student's *t*-test or with the Mann-Whitney U test depending on the normality determined by the Kolmogorov-Smirnov test.

Results

During the operation no complications were observed. A pathogen was found in 12 cases, and in 13 cases no pathogen could be identified. The most common bacteria were *Staphylococcus aureus* ($n=6$), followed by coagulase-negative staphylococci ($n=3$), *Escherichia coli* ($n=2$) and *Proteus mirabilis* ($n=1$).

In the postoperative course no implant-related complications were seen. Three patients died postoperatively: one patient did not recover from cardiac failure two weeks after the staged anterior procedure, a second patient died after a cardiac arrest six months after the operation and a third patient died eight months postoperatively secondary to pulmonary artery embolism. All remaining 22 patients could be observed up to the three-year follow-up.

No implant failure or recurrence of infection infection recurrence was seen in any patient. At the final follow-up the WBC count was $7.6 \pm 2.0/\text{nl}$, and the final CRP was below 5 mg/l in all patients. The sagittal profile was corrected in all cases (Figs. 1 and 2). From preoperative imaging to postoperative radiographs a mean correction of $12.3 \pm 11.9^\circ$ was achieved. From postoperative radiographs to the final follow-up there was a mean segmental loss of correction of $3.4 \pm 2.1^\circ$ into kyphosis, which was statistically not significant. Six patients with preoperative sensorimotor deficit recovered completely by the time of the final follow-up. One patient did not recover completely before he died due to pulmonary artery embolism.

The pain VAS dropped from 8.9 ± 1.0 (7; 10) postoperatively to 3.0 ± 0.8 (2; 4) ($p < 0.001$) after one year to 2.1 ± 1.7 (0; 4) after three years ($p < 0.001$). The ODI was 50 ± 18 (31; 66) after one year and improved to 23 ± 14 (11; 47) after three years ($p < 0.001$).

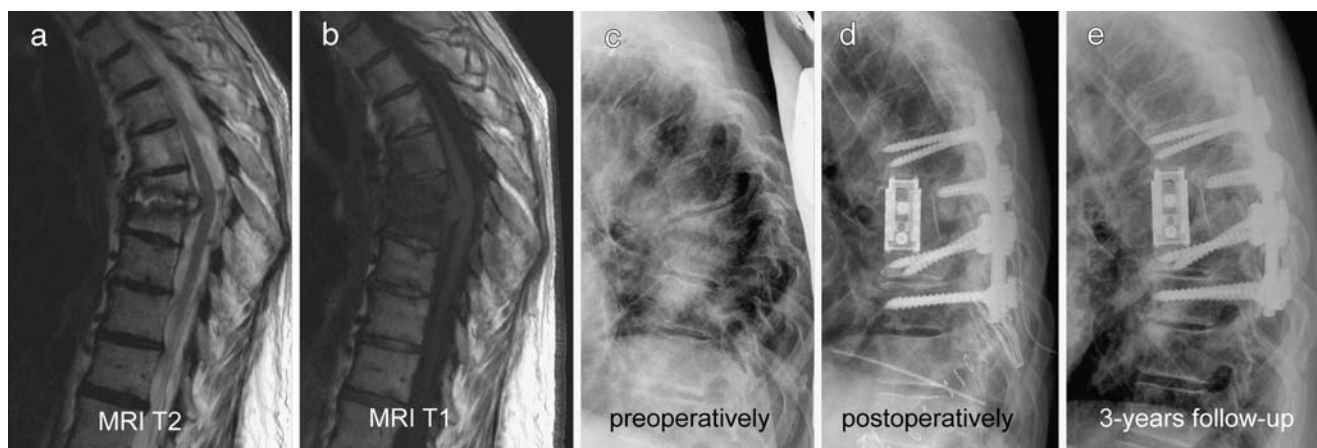


Fig. 1 This 76-year-old female patient presented with kyphosis due to destructive spondylodiscitis T7/8 with epidural abscess (a–c). The large defect after sagittal profile reconstruction and posterior instrumentation

was bridged by an expandable titanium cage and autologous bone grafting (d). Three years postoperatively no kyphotic sintering was found (e)

Discussion

In the majority of cases pyogenic spondylodiscitis can be treated non-operatively, even though antibiotic penetration into the disc space is remarkably low [3]. If bony structures are involved and large defects, deformities as well as abscesses are prevalent, surgical treatment is often required modalities [21]. The mainstays of successful surgical treatment are a radical débridement, abscess evacuation and decompression, followed by correction of the deformity and stabilisation of the affected segments. The long-term success of the surgical treatment depends on a stable fusion by bone grafting [5, 6, 17].

For decades stabilisation of the osteomyelitic spine with metal implants was avoided, because of bacterial adherence to metal surfaces. The *in vitro* experiments of Ha et al. [4] found a diverse bacterial adherence to commonly used metal surfaces dependent on biofilm formation and species.

Despite the historical problems with implant infection, the availability of titanium implants for anterior and posterior stabilisation has resulted in their use in the setting of spinal infection [8]. This was thought to be effective because some titanium surfaces show reduced bacterial biofilm adherence [4], and the local rich muscle covering with high vascularisation causes high immunity on site [7]. Nevertheless, Shad et al. [18] found in all patients despite successful fusion bacterial colonisation on implants after removal within a year after cervical spondylodiscitis treatment ($n=4$). Knowledge about the use of titanium cages in the infected anterior spine is still limited, but more and more authors advocate the use of cages in a 360° fusion, because of the improved correction of deformity [2, 9–12, 16, 17].

Fayazi et al. [2] used titanium mesh cages in a staged anterior-posterior procedure in 11 patients with spondylodiscitis. Revision was necessary in one patient because of

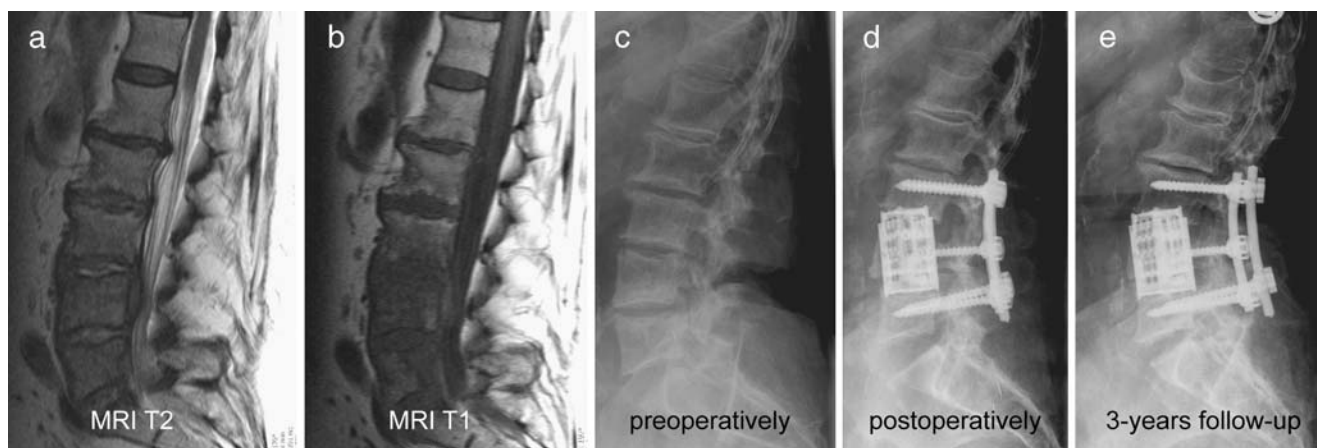


Fig. 2 This 72-year-old female patient presented with spondylodiscitis L3/4 and L4/5 with epidural abscess (a–c). The large defect after anterior débridement, including corpectomy L4, and abscess evacuation was

bridged by an expandable titanium cage and autologous bone grafting (d). Three years postoperatively no loss of correction was seen (e)

hardware failure. One patient developed pseudarthrosis. No patients showed Tony signs of recurrence of infection.

Korovessis et al. [9, 10] implanted titanium mesh cages in 14 and 17 patients with pyogenic spondylodiscitis. No loss in correction was found after a mean follow-up of 45 months. Revision was necessary in one patient.

The 22 patients with spondylodiscitis in whom Kuklo et al. [11] implanted titanium mesh cages with additional posterior instrumentation and had only minimal settling of the cage. Surgical revision without implant removal was necessary in two patients.

Lerner et al. [12] investigated the use of anterior titanium mesh cages in 43 patients with spondylodiscitis. They found a mean loss of correction of 1.4° at a mean follow-up of 2.5 years. With the exception of one patient who required anterior revision, all infections were eradicated.

The results of the largest series of patients with spondylodiscitis were published by Ruf et al. [17], who investigated the use of anterior titanium mesh cages in combination with posterior instrumentation in spinal reconstruction after spondylodiscitis in 88 patients. In three cases as many as three vertebrae had to be replaced. They found complete healing in all patients and adequate correction of the sagittal profile.

The study by Ozturk et al. [14] presents excellent long-term results in the treatment of spondylodiscitis with staged and non-staged procedures in 56 patients, 50 of whom received anterior titanium cages. They found solid fusion in all cases and a mean correction of deformity between 16 and 17.1° .

Recently the results of using titanium mesh cages in 22 patients by our study group were published [16]. No infection recurrence was seen after a mean follow-up of 36 months.

In an investigation by Aryan et al. [1] bone morphogenic protein-2 (BMP-2) was used with allograft in anterior titanium cages in ten patients and compared with titanium cages filled with autologous bone graft in five patients. For the mean follow-up of 20 months no recurrent infection was seen and solid fusion was found both in the BMP-2 and in the autograft group.

Expandable titanium cages have several advantages compared to non-expandable anterior devices. They require less surgical exposure because they can be expanded within the defect. Thus they can be manoeuvred more easily around the large vessels to the lower anterior spine. Furthermore distraction can be applied against the anteriorly acting compressive forces leading to effective anterior load uptake without the necessity of further intraoperative turning of the patient to perform posterior compression.

Our findings presented here are unique since they describe the three-year follow-up results of using expandable titanium cages in defects after destructive spinal infection.

Despite the wide availability of expandable titanium implants, few results of spondylitic spinal column reconstruction with these devices have been published to date.

Ulmar et al. [22] presented an investigation in 40 patients who received vertebral body replacement with an anterior expandable cage (Obelisc, Ulrich, Ulm, Germany) after posterior instrumentation. The mean follow-up was 16 months. There were five patients in this group with spondylodiscitis who had a mean loss of correction of only 1.6° in the postoperative course. Loss of correction typically occurred during the first 3 months.

These findings correlate with our results which are highly in favour of expandable devices for large defects. Even though implant designs differ widely, the biomechanical properties are similar, if additional posterior instrumentation is performed. Therefore expandable titanium cages are possibly an effective alternative to currently used titanium mesh cages, provided that adequate surgical techniques are applied. Radical débridement, correction of deformity with rigid stabilisation and bony fusion are the backbone of successful surgery in vertebral osteomyelitis.

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